

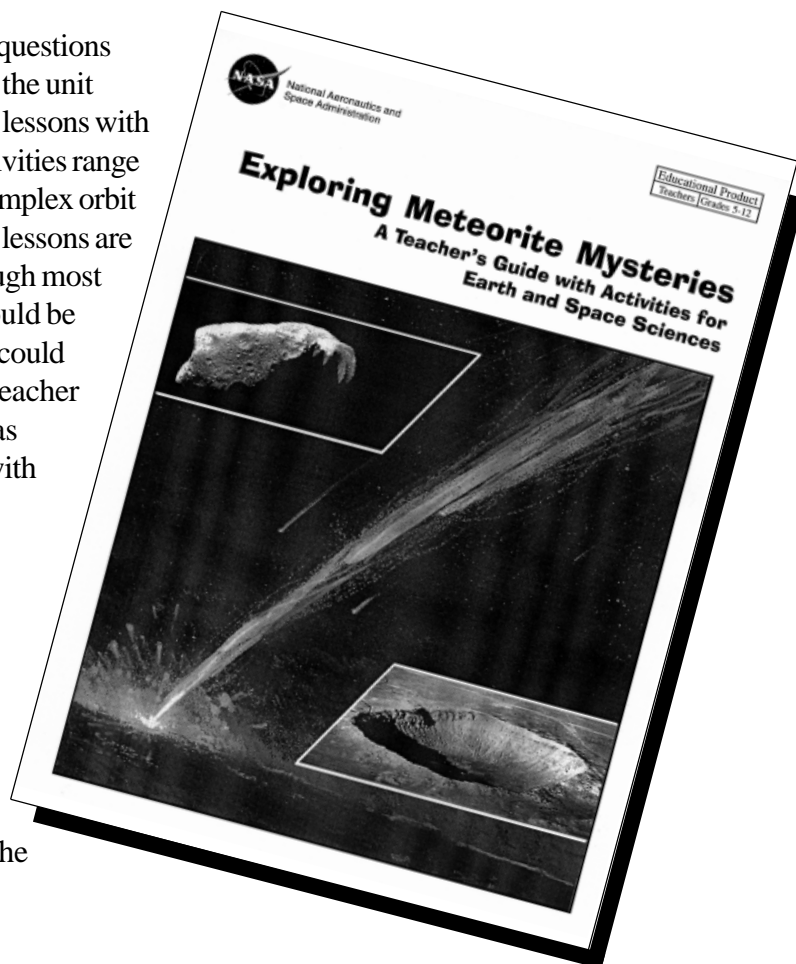
About *Exploring Meteorite Mysteries*

Teachers and scientists designed this book to engage students in inquiry science and to extend science with interdisciplinary connections. The study of meteorites provides a unifying theme that links almost every aspect of Earth and planetary science with mathematics, physics, chemistry and even biology. The effects of meteorite impacts have serious implications for social science. The activities in this book are designed for upper elementary to high school levels. Many of the lessons begin with a simple activity and build to more complex ones. The Curriculum Content Matrix, Lesson Topic Planner and Lesson Sequence Suggestions may assist teachers in integrating the meteorite activities with their existing Earth science curricula and standards requirements.

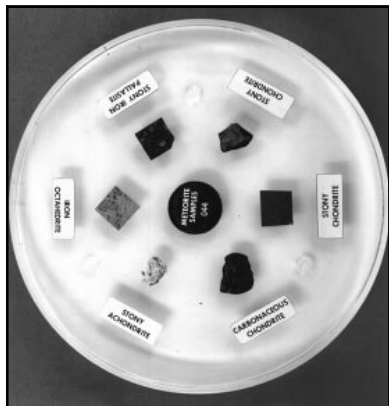
The Teacher's Guide, *Meteorites, Clues to Solar System History*, gives a broad introduction to many aspects of meteorite science. It tells the story of solar system history from the formation of the planets to catastrophic impacts on Earth. It helps the students learn how scientists use studies of these rocks from space to decipher that history. The Meteorite ABC's and Solar System ABC's Fact Sheets contain important information about meteorites and bodies in the solar system in convenient table format.

The Activities are divided into units based on key questions students may ask about meteorites. For example, the unit entitled "Where do they come from?" contains six lessons with many activities that explore that question. The activities range from introductory impact experiments to rather complex orbit constructions that use beginning geometry. Some lessons are designed to use the Meteorite Sample Disk, although most lessons do not require the disk. All the lessons could be taught in the science classroom, but many lessons could be used in other areas. The lessons include both teacher and student pages, both of which may be copied as needed. Measurements are given in metric units with some English units in parentheses for common household items.

The book concludes with a Glossary and an Education Resources section. Key words that appear in bold in the Teachers' Guide or as vocabulary in the Activities are defined in the glossary. The Education Resources section lists specific books and supporting materials for meteorites. It also provides a guide to accessing the broad range of NASA resources for educators.



About the Meteorite Sample Disk



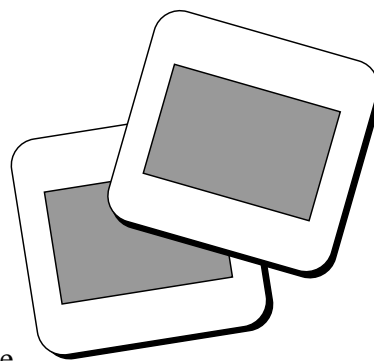
The Meteorite Sample Disk contains six labeled meteorites embedded in a 15 cm plastic disk. These pieces of asteroids represent the products of basic planetary processes: accretion, differentiation, volcanism and impact. Educators may borrow the Meteorite Sample Disk containing these rocks from space to help students learn about the early history of the solar system. The Meteorite Sample Disk package contains the disk, a copy of this activity guide, and the *Exploring Meteorite Mysteries* slide set described below.

To borrow the Meteorite Sample Disk educators must first attend a short certification briefing on security requirements and handling procedures.

This is the same certification as for borrowing the Lunar Sample Disk. These briefings are given by NASA staff at locations around the country. Following certification educators may request the loan of the disks for periods of one to two weeks. Written requests should be sent to the NASA Educator Resource Center in your geographic area at least one month before the requested loan date. For more information on scheduling certification and request procedures, educators should contact their Educator Resource Center at the locations given on page B.2 at the end of this book.

About the Slide Set

A set of forty-eight 35 mm slides has been prepared to supplement the activities in this *Exploring Meteorite Mysteries* book. The slides and narrative descriptions are divided into four parts. The first 25 slides present a general introduction to meteorites and what they tell us about the history of the solar system. It begins with observations of meteorite falls, depicts meteorites and their formation processes, and concludes with their impact on life and future exploration of the solar system. The remaining three parts are more detailed sections for use with various lessons in the activity guide. These sections reuse some of the slides from the introduction. One section on impact craters illustrates craters on Earth, the Moon and other planets. The next section on classification and formation depicts various meteorite types and the processes of accretion, differentiation, volcanism, and impact. The final section shows collection, curation, and research on Antarctic meteorites.



The slide set is distributed to educators with the Meteorite Sample Disk. Anyone desiring a permanent copy of the slide set may order it at cost from NASA Central Operation of Resources for Educators (CORE). The address and various contacts for CORE are listed on page B.2 at the back of this book.

Science Process Skills

for Exploring Meteorite Mysteries

This chart is designed to assist teachers in integrating the activities contained in the guide with existing curricula.

Unit	Lesson	Observing	Classifying	Communicating	Measuring	Inferring	Predicting	Experimental Design	Gathering and Organizing Data	Controlling Variables	Developing a Hypothesis	Extending Senses	Researching	Team Work	Mathematics	Interdisciplinary	Introductory Activity	Advanced Activity
<i>Mysterious Meteorites</i>	Lesson 1 Noblesville Fall	✓	✓	✓		✓	✓									✓	✓	
<i>"Where Do They Come From?"</i>	Lesson 2 Follow the Falling Meteorite	✓		✓	✓	✓	✓	✓	✓			✓		✓	✓	✓	✓	✓
	Lesson 3 Searching for Meteorites	✓		✓	✓	✓	✓	✓	✓	✓	✓			✓	✓	✓	✓	
	Lesson 4 The Meteorite-Asteroid Connection	✓			✓		✓							✓	✓		✓	✓
	Lesson 5 Looking at Asteroids	✓			✓	✓		✓	✓			✓			✓		✓	✓
	Lesson 6 Impact Craters—Holes in the Ground!	✓		✓	✓	✓	✓	✓	✓	✓	✓			✓	✓		✓	✓
	Lesson 7 Crater Hunters	✓		✓		✓	✓	✓	✓		✓		✓	✓	✓	✓	✓	✓
<i>"What Are They?"</i>	Lesson 8 Edible Rocks	✓		✓								✓		✓	✓	✓	✓	

Unit	Lesson	Observing	Classifying	Communicating	Measuring	Inferring	Predicting	Experimental Design	Gathering and Organizing Data	Controlling Variables	Developing a Hypothesis	Extending Senses	Researching	Team Work	Mathematics	Interdisciplinary	Introductory Activity	Advanced Activity
<i>"What Are They?"</i>	Lesson 9 Meteorite Sleuths!	✓	✓	✓	✓	✓	✓		✓			✓			✓	✓		
<i>"How Did They Form?"</i>	Lesson 10 Building Blocks of Planets	✓	✓	✓		✓	✓							✓		✓	✓	
	Lesson 11 Changes Inside Planets	✓	✓	✓	✓	✓	✓		✓	✓		✓		✓	✓		✓	
	Lesson 12 Building Blocks of Life	✓		✓	✓	✓	✓	✓		✓				✓	✓	✓	✓	✓
	Lesson 13 Solving a Mystery	✓	✓	✓	✓	✓	✓		✓			✓			✓			✓
<i>"What Effect Do They Have?"</i>	Lesson 14 Direct Hit at the K-T Boundary	✓		✓	✓	✓	✓	✓	✓	✓		✓		✓	✓	✓	✓	✓
	Lesson 15 Historical Meteorite Falls			✓		✓							✓		✓	✓	✓	
	Lesson 16 Near Miss			✓		✓							✓	✓		✓	✓	✓
<i>"How Can I Use Them?"</i>	Lesson 17 Asteroid Resources	✓		✓	✓			✓	✓			✓	✓	✓	✓	✓	✓	✓
<i>"Is There a Career for Me?"</i>	Lesson 18 Antarctic Meteorite Teams	✓		✓		✓							✓	✓	✓	✓		✓
<i>"What Can We Believe?"</i>	Lesson 19 The Daily Shooting Star			✓		✓							✓		✓	✓	✓	✓

Science and Mathematics Standards for Exploring Meteorite Mysteries

	Science as Inquiry	Structure and Energy of the Earth System	Origin and History of the Earth	Earth in the Solar System	Geochemical Cycles	Physical Science	Populations and Ecosystems	Understanding about Science and Technology	Science in Personal and Social Perspectives	History and Nature of Science		Problem Solving	Measurement	Computation and Estimation	Communication	Geometry and Advanced Mathematics	Statistics and Probability	Number and Number Relationships	Patterns and Functions
Lesson 1 Noblesville Fall	✓		✓	✓				✓	✓	✓									
Lesson 2 Follow the Falling Meteorite	✓	✓		✓		✓		✓		✓		✓	✓	✓	✓	✓	✓		✓
Lesson 3 Searching for Meteorites	✓	✓	✓	✓				✓		✓		✓		✓	✓		✓	✓	✓
Lesson 4 The Meteorite- Asteroid Connection	✓	✓	✓	✓		✓		✓		✓		✓	✓	✓	✓	✓	✓	✓	✓
Lesson 5 Looking at Asteroids	✓		✓			✓		✓		✓		✓	✓		✓		✓	✓	✓
Lesson 6 Impact Craters— Holes in the Ground!	✓	✓	✓			✓		✓				✓	✓	✓	✓		✓		✓
Lesson 7 Crater Hunters	✓	✓	✓		✓			✓	✓	✓		✓		✓	✓		✓		✓
Lesson 8 Edible Rocks	✓	✓							✓	✓		✓		✓	✓				✓

	Science as Inquiry	Structure and Energy of the Earth System	Origin and History of the Earth	Earth in the Solar System	Geochemical Cycles	Physical Science	Populations and Ecosystems	Understanding about Science and Technology	Science in Personal and Social Perspectives	History and Nature of Science		Problem Solving	Measurement	Computation and Estimation	Communication	Geometry and Advanced Mathematics	Statistics and Probability	Number and Number Relationships	Patterns and Functions
Lesson 9 Meteorite Sleuths	✓		✓		✓	✓		✓				✓	✓	✓	✓		✓		✓
Lesson 10 Building Blocks of Planets	✓	✓	✓	✓	✓	✓		✓							✓				
Lesson 11 Changes Inside Planets	✓	✓	✓	✓	✓	✓		✓				✓	✓						
Lesson 12 Building Blocks of Life	✓	✓	✓	✓	✓	✓		✓	✓	✓		✓	✓		✓				
Lesson 13 Solving a Mystery	✓					✓		✓	✓			✓	✓	✓	✓				✓
Lesson 14 Direct Hit at the K-T Boundary	✓		✓	✓	✓		✓	✓	✓	✓		✓	✓	✓	✓		✓	✓	✓
Lesson 15 Historical Meteorite Falls	✓		✓	✓			✓		✓	✓						✓			
Lesson 16 Near Miss			✓	✓			✓	✓	✓	✓					✓				
Lesson 17 Asteroid Resources	✓	✓						✓	✓	✓		✓	✓	✓	✓		✓	✓	✓
Lesson 18 Antarctic Meteorite Teams	✓						✓	✓	✓	✓					✓				✓
Lesson 19 The Daily Shooting Star	✓	✓	✓	✓			✓	✓	✓	✓					✓			✓	

Lesson Topic Planner

for Exploring Meteorite Mysteries

This matrix indicates some of the lessons in Exploring Meteorite Mysteries that could be used to enhance selected science topic themes frequently used in Earth/Space Science curricula.

Metric and Scientific Method (*students use metric measurements in activities*)

- Lesson 2** Follow the Falling Meteorite
- Lesson 4** The Meteorite-Asteroid Connection
- Lesson 6** Impact Craters — Holes in the Ground!
- Lesson 9** Meteorite Sleuths

Water (*fresh and oceans*)

- Lesson 12** Building Blocks of Life
- Lesson 14** Direct Hit at the K-T Boundary
- Lesson 16** Near Miss
- Lesson 17** Asteroid Resources

Atmosphere/Climate/Weather

- Lesson 14** Direct Hit at the K-T Boundary
- Lesson 16** Near Miss

Rocks/Minerals/Geologic Time

- Lesson 1** Noblesville Fall
- Lesson 6** Impact Craters — Holes in the Ground!
- Lesson 7** Crater Hunters
- Lesson 8** Edible Rocks
- Lesson 9** Meteorite Sleuths
- Lesson 10** Building Block of Planets
- Lesson 11** Changes Inside Planets
- Lesson 12** Building Blocks of Life
- Lesson 13** Solving a Mystery
- Lesson 14** Direct Hit at the K-T Boundary

Planet Dynamics

Earthquakes

- Lesson 14** Direct Hit at the K-T Boundary
- Lesson 16** Near Miss
- Lesson 6** Impact Craters — Holes in the Ground!

Plate Tectonics and Volcanism

- Lesson 7** Crater Hunters
- Lesson 10** Building Blocks of Planets
- Lesson 11** Changes Inside Planets
- Lesson 14** Direct Hit at the K-T Boundary

Weathering and Erosion

- Lesson 6** Impact Craters — Holes in the Ground!
- Lesson 7** Crater Hunters

Natural Resources/National Parks

- Lesson 3** Searching for Meteorites
- Lesson 10** Building Blocks of Planets
- Lesson 11** Changes Inside Planets
- Lesson 12** Building Blocks of Planets
- Lesson 17** Asteroid Resources

Historical Connections/ People/Careers

- Lesson 1** Noblesville Fall
- Lesson 7** Crater Hunters
- Lesson 14** Direct Hit at the K-T Boundary
- Lesson 15** Historical Meteorite Falls
- Lesson 16** Near Miss
- Lesson 18** Antarctic Meteorite Teams
- Lesson 19** The Daily Shooting Star

Space (*Stars and Solar System*)

- Lesson 1** Noblesville Fall
- Lesson 2** Follow the Falling Meteorite
- Lesson 3** Searching for Meteorites
- Lesson 4** The Meteorite-Asteroid Connection
- Lesson 5** Looking at Asteroids
- Lesson 10** Building Blocks of Planets
- Lesson 11** Changes Inside Planets
- Lesson 17** Asteroid Resources

Lesson Sequence Suggestions

for Exploring Meteorite Mysteries

Lesson Groups are suggested for one or a combination of several of the following criteria: time available in the classroom, theme or topic of existing curricula, Meteorite Sample Disk availability, and interdisciplinary connections. More than one lesson could be accomplished in a 90-minute class. Some lessons may be inserted directly into existing Earth/Space Science curricula as enrichment activities without a more extensive meteorite focus.

Activities Without Meteorite Sample Disk

Stand alone activities for one or two class periods without Meteorite Sample Disk.

- Lesson 1** Noblesville Fall
- Lesson 2** Follow the Falling Meteorite
- Lesson 4** The Meteorite-Asteroid Connection:
Orbits in the inner Solar System
- Lesson 6** Impact Craters —Holes in the Ground!
- Lesson 7** Crater Hunters
- Lesson 8** Edible Rocks
- Lesson 10** Building Blocks of Planets (non-Meteorite Sample Disk activities only)
- Lesson 11** Changes Inside Planets (non-Meteorite Sample Disk activities only)
- Lesson 12** Building Blocks of Life
- Lesson 14** Direct Hit at the K-T Boundary
- Lesson 15** Historical Meteorite Falls
- Lesson 16** Near Miss
- Lesson 18** Antarctic Meteorite Teams

One week without Meteorite Sample Disk. (*Emphasizing basic meteorite background and hands-on activities on impact cratering.*)

- Lesson 1** Noblesville Fall
- Lesson 2** Follow the Falling Meteorite
- Lesson 3** Searching for Meteorites
- Lesson 6** Impact Craters —Holes in the Ground!

One or two weeks without Meteorite Sample Disk. (*Emphasizing basic meteorite background and hands-on activities about the origin and physical characteristics of meteorites.*)

- Lesson 1** Noblesville Fall
- Lesson 8** Edible Rocks
- Lesson 10** Building Blocks of Planets
- Lesson 11** Changes Inside Planets
- Lesson 12** Building Blocks of Life
- Lesson 13** Solving a Mystery

Activities With Meteorite Sample Disk

One or two class periods with Meteorite Sample Disk.
(*other lessons do not need the Disk*)

Sequence of :

- Lesson 1** Noblesville Fall
- Lesson 10** Building Blocks of Planets
- Lesson 11** Changes inside Planets

or

- Lesson 8** Edible Rocks
- Lesson 10** Building Blocks of Planets
- Lesson 11** Changes Inside Planets

or

- Lesson 8** Edible Rocks
- Lesson 9** Meteorite Sleuths!

One week with a Meteorite Sample Disk.

Sequence of :

- Lesson 1** Noblesville Fall
- Lesson 8** Edible Rocks
- Lesson 10** Building Blocks of Planets
- Lesson 11** Changes Inside Planets

or

- Lesson 1** Noblesville Fall
- Lesson 8** Edible Rocks
- Lesson 9** Meteorite Sleuths!